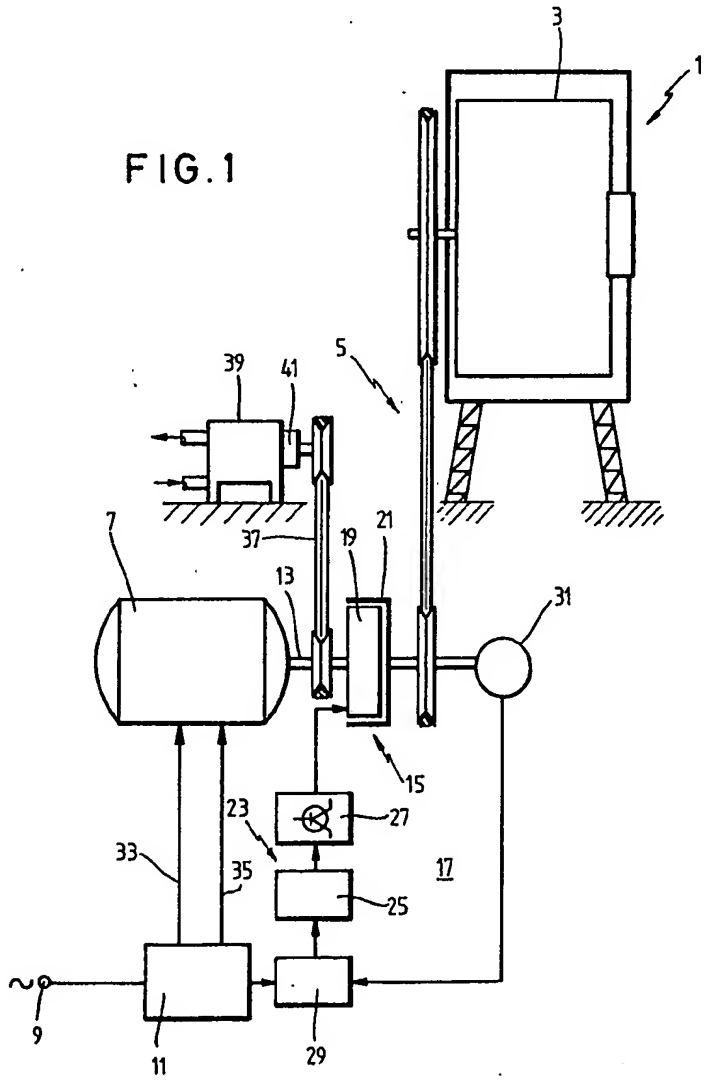
(12) UK Patent Application (19) GB (11) 2 087 933 A

(21) Application No 8134120
(22) Date of filing 12 Nov 1981
(30) Priority data
(31) 3044033
3140405
(32) 22 Nov 1980
12 Oct 1981
(33) Fed. Rep. of Germany (DE)
(43) Application published
3 Jun 1982
(51) INT CL³
D06F 37/36
(52) Domestic classification
D1A B2 F1A F5B1 K1
L1D1A L1D2A1 L2B L2E
L4X Q2C3 Q2D7
(56) Documents cited
None
(58) Field of search
D1A
(71) Applicants
Fichtel & Sachs AG,
62 Ernst-Sachs-Strasse,
Schweinfurt, Germany,
Federal Republic of
Germany
(72) Inventor
Gerhard Dumbser
(74) Agents
Matthews, Haddan & Co.,
Haddan House, 33,
Elmfield Road, Bromley,
Kent, BR1 1SU

(54) Washing machine drive system

(57) The washing machine drive system comprises a pole changeable alternating current motor (7) which drives a drum (3) of the drum-type washing machine (1) through an induction coupling (15) and a rotation speed-reducing belt transmission (5). A programme control system (11) switches on the motor (7) with low pole number (for example 2) in spin-drying operation and with high pole number (for example 12) in washing operation. The drive-output rotation speed of the induction coupling (15) is kept both in spin-drying operation and in washing operation at a rotation speed value predetermined by the programme control system (11), by a rotation speed regulator circuit (17). The rotation speed regulator circuit (17) gives off direct current pulses to the induction coupling (15), the pulse rate or pulse width of which is variable in dependence upon the actual rotation speed of the induction coupling (15).

FIG.1



GB 2 087 933 A

2997033

FIG.1

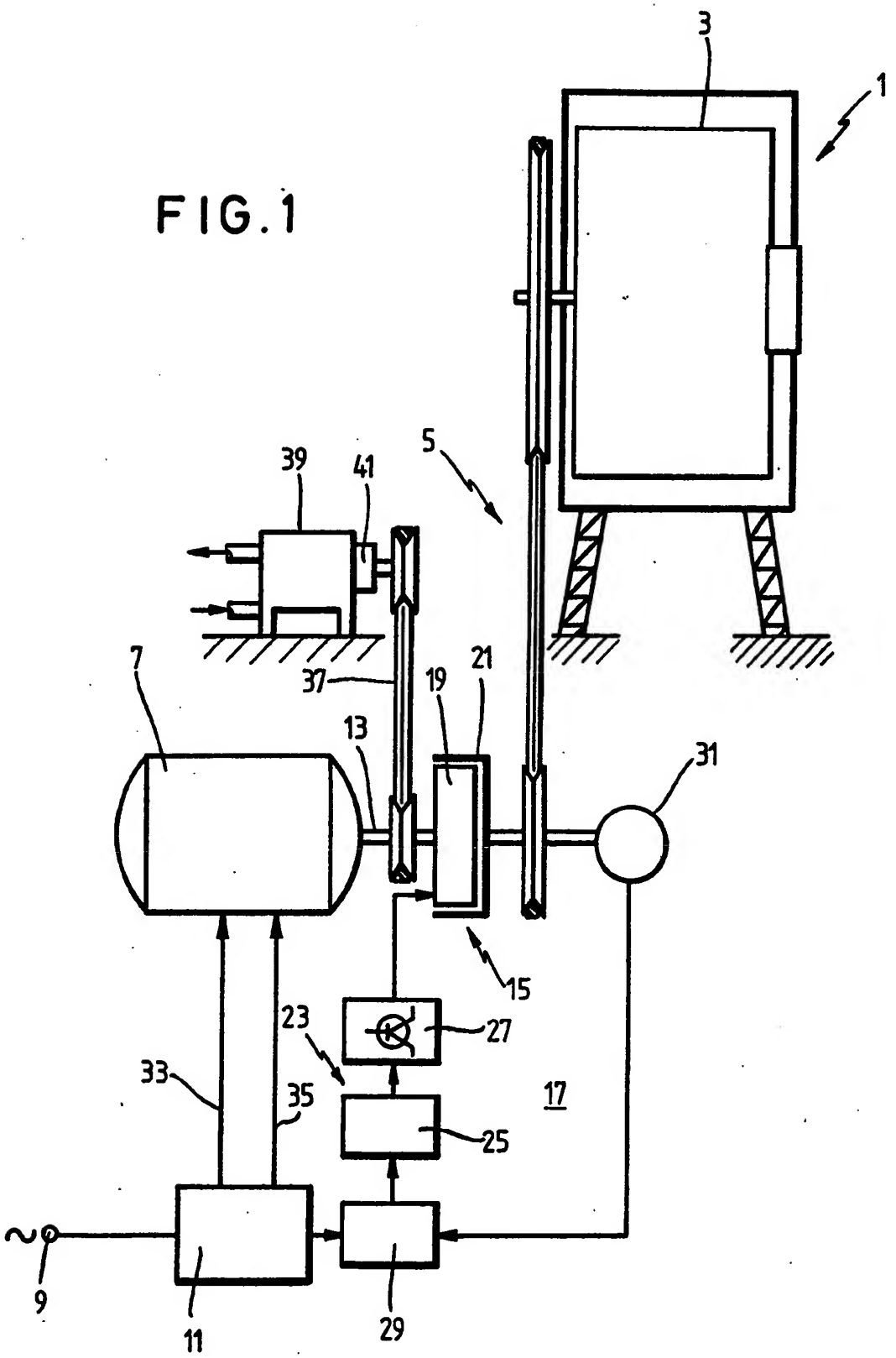
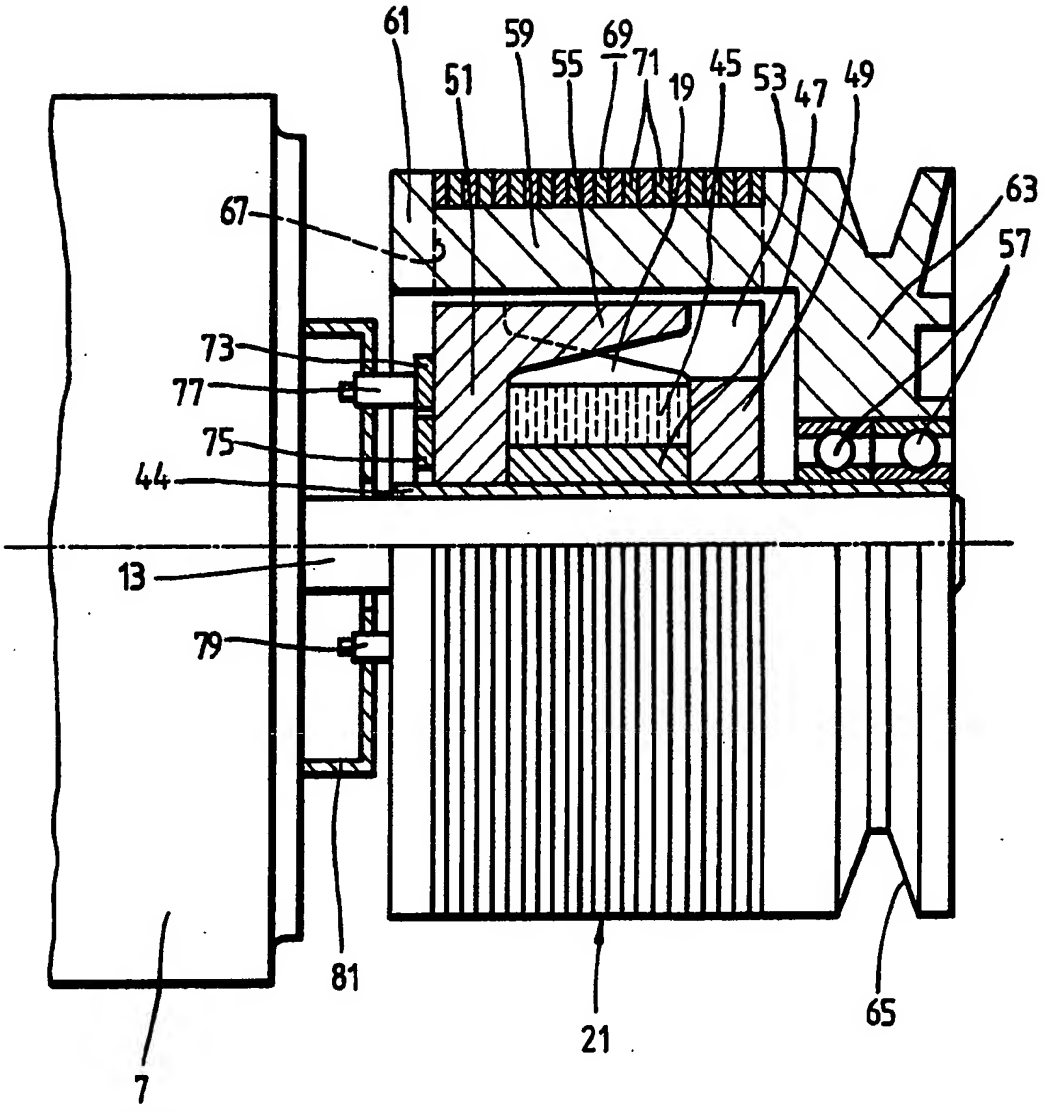


FIG. 2



SPECIFICATION

Washing machine drive system

The invention relates to a drive apparatus for a rotating drum of a washing machine operable with at least one washing rotation speed and at least one spin-drying rotation speed, having an electric motor, an induction coupling interposed in the force transmission path between the electric motor and the drum, and a program control system which controls the washing operation and the spin-drying operation.

In conventional drum-type washing machines the washing drum is driven in washing operation at about fifty revolutions per minute, while the spin-drying rotation speed lies at about 1,000 revolutions per minute. The rotation speed spread of 1:20 necessary for this purpose cannot be achieved exclusively by switching over the pole number of the electric motor, if only a single electric motor is to be provided for the drive of the drum. Such pole-changeable motors therefore drive the drum through a transmission which can be changed over in dependence upon the motor rotation speed, and the centrifugal actuation. Such geared motors however can drive the drum essentially only with two rotation speeds fixed by construction.

In order that the washing machine may be operated even with more than one washing rotation speed and more than one spin-drying rotation speed, it is known to use electronically regulated commutator motors to drive the drum. Such drive systems however in washing operation consume a relatively high current and are extraordinarily noisy by reason of their commutator construction style, in spin-drying operation.

From German Utility Model No. 66 03 904 a washing machine is known the drum of which is driven in washing operation by a first motor, designed for the washing rotation speed, and in spin-drying operation by a separate second electric motor which is dimensioned for the spin-drying rotation speed. In order to avoid unnecessary drive losses, each of the two motors is coupled with the drum through an electrically controllable coupling. The coupling of the washing motor is a conventional magnetically operable coupling which is either fully engaged or fully disengaged. The coupling of the spin-drying motor is formed as induction coupling and is engaged according to a predetermined program in the starting up of the drum in spin-drying operation, so that the laundry to be spin-dried can apply itself uniformly to the internal circumference of the drum.

Details of electric drive systems the drive-output rotation speed of which is variable by means of an induction coupling are known from British Patent No. 910,884 and German Patent No. 1,488,483. The drive-output rotation speed of the induction coupling is detected by means of a rotation speed indicator. A regulator circuit controls the excitation of the induction coupling so that the drive-output rotation speed remains substantially constant, independently of the loading of the motor.

It is the problem of the invention to indicate a way in which with a single electric motor the drum of a washing machine can be driven with substantially freely selectable rotation speed in a very large range of rotation speeds. Especially in washing operation, minimum possible electric losses should here occur and in spin-drying operation the noise generation should be low. As a whole the constructional expense should remain low.

On the basis of the known drive apparatus as initially explained this problem is solved in that the electric motor is formed as a pole-changeable alternating current motor which the program control system switches on in spin-drying operation with a first pole number and in washing operation with a second pole number, higher than the first pole number, and in that the induction coupling is connected to a rotation speed regulator circuit which maintains the drive-output rotation speed of the induction coupling at rotation speed values predetermined by the program control system in spin-drying operation and washing operation, by regulation of the excitation of the induction coupling.

By reason of these measures a maintenance-free, robust and quiet induction motor can be used which consumes a low motor current both in spin-drying operation and in washing operation. This motor is preferably a single-phase alternating current motor. In contrast to conventional rotation speed-regulable washing machine drive systems, the reduction of the drive-output rotation speed of the motor is not at the cost of heating of the motor, since both in washing operation and in spin-drying operation the motor works with its rated rotation speed determined by the number of poles. The cooling of the motor is thus guaranteed. The control current of the induction coupling is very low, so that cost-favourable regulator circuits can be used.

It is sufficient if the electric motor is changeable between two pole numbers in order that the drum rotation speeds required in spin-drying operation and washing operation may be realised. The lower pole number is dimensioned so that the maximum desired spin-drying rotation speed is reached. The rotation speed spread of the electric motor and thus the ratio of the changeable pole numbers preferably lies between 6:1 and 10:1. So that the higher pole number which is to be switched on in washing operation remains within technically simply realisable limits, the first pole number which determines the spin-drying operation should be as low as possible. The first pole number expediently amounts to 2 and the second pole number to 12. Since with a pole number of 2 the drive-output rotation speed of the motor is greater than the requisite drum rotation speed in spin-drying operation, the electric motor is coupled with the drum through a reduction gearing, preferably a belt gearing. The reduction

ratio reduces the drive-output rotation speed expediently in a ratio between 2.5:1 and 3.5:1.

The rotation speed regulation circuit controls the slip of the induction coupling between values of about 0.85 and approximately 0. In operation with the maximum spin-drying rotation speed the induction coupling is fully energised, so that the slip approaches the value 0. In washing operation the slip amounts to about 0.5 to 0.85.

The exciter winding of the induction coupling is preferably fed with direct-current pulses from a pulse driver circuit of the rotation-speed regulator circuit, which pulses the pulse drive circuit gives off with a pulse rate or pulse width dependent upon the drive-output rotation speed of the induction coupling. Since the exciter current of the induction coupling is relatively small, a pulse driver circuit with a transistor output stage can be used. Compared with relatively expensive phase control systems with thyristors, the constructional expense of such a pulse driver circuit is low.

In a preferred form of embodiment the alternating current motor is coupled both through the induction coupling with the drum and through at least one additional permanent magnetically energised coupling with at least one auxiliary unit of the washing machine, especially a washing liquor pump or a fan. One and the same motor is used for driving both the drum and all secondary units. The secondary units can be operated together with the drum or with the drum stationary, according to the excitation of the induction coupling.

The induction coupling should firstly be capable of being produced with low manufacturing expense, that is at favourable cost, and secondly should have maximum efficiency. An induction coupling satisfying these requirements comprises a pole spider having an exciter winding generating an axially directed magnetic field, and an inductor rotating coaxially with and in relation to the pole spider. The pole spider in turn has a yoke with a yoke plate on each of the two axial sides of the exciter winding, the yoke plates carrying a plurality of pole pieces distributed at equal intervals over their circumference, which pieces are arranged in the circumferential direction in each case between the pole pieces of the other yoke plate respectively. The exciter winding thus generates magnetic fields with alternating polarity, directed in the circumferential direction, between the pole pieces. The inductor is preferably formed as a squirrel-cage rotor and consists of a metal die-casting which comprises two short-circuit rings coaxial with the pole spider and arranged at an axial distance from one another and a plurality of axially extending short-circuit webs between the short-circuit rings, distributed over the circumference, and integrally connected with the short-circuit rings. The angular intervals of the short-circuit webs are preferably equal to the angular intervals of adjacent pole pieces. One of the short-circuit rings at the same time forms a bearing hub for an overhung mounting of the inductor on the motor shaft or a separate shaft connected fast in rotation with the motor shaft. An inductor of the above-described kind can be produced at favourable cost. This is true especially when the short-circuit ring forming the bearing hub is at the same time formed integrally as drive-output belt pulley.

To improve the efficiency of the induction coupling the short-circuit webs are moulded into axial grooves of a yoke of annular soft iron plate parts stacked axially with insulation from one another.

The invention is to be explained in greater detail below, by reference to drawings, wherein:—

FIGURE 1 shows a diagrammatic representation of a drum-type washing machine with a drive system in accordance with the invention, and

FIGURE 2 shows a diagrammatic, partially axially sectional lateral elevation of an induction coupling of the drive system according to Figure 1.

Figure 1 shows a drum-type washing machine 1, the drum 3 of which, which is rotatably mounted about a substantially horizontal axis, is driven through a reduction belt transmission 5 both in washing operation and in spin-drying operation by a single-phase alternating current motor 7. A program control system 11 connected at 9 to the alternating current mains controls the washing and spin-drying operations of the drum-type washing machine 1 and the rotation speed of the drum 3 according to the selectably predetermined washing or spin-drying program.

The spin-drying rotation speed lies at about 1,000 revolutions per minute, while the washing rotation speed lies in the order of magnitude of 50 revolutions per minute. This corresponds to a rotation speed spread of 20:1. In order to achieve this rotation speed spread and at the same time to be able to vary the rotation speed for spin-drying or the washing rotation speed in dependence upon the spin-drying or washing program set on the program control system 11, the alternating current motor 7 is formed as a pole-changeable induction motor and between its drive-output shaft 13 and the belt transmission 5 an induction coupling 15 is interposed the slip and thus the drive-output rotation speed of which are kept at an ideal rotation speed value predetermined by the programme control system 11, by means of a rotation speed regulator circuit 17. The induction coupling 15 comprises a pole spider 19 seated on the drive-output shaft 13 and provided with an exciter winding, which generates eddy currents in a coaxial inductor 21 rotatable in relation thereto, which set the inductor 21 connected with the belt transmission 5 in rotation when the pole spider 19 is driven by the alternating current motor 7. In the example of embodiment as illustrated the pole spider 19 is seated on the drive-output shaft of the alternating current motor 7. The converse arrangement in which the inductor 21 is seated on the drive-output shaft 13 is also suitable.

The slip of the induction coupling 15 is dependent upon the excitation of the pole spider 19. The exciter current is fed from a pulse driver

circuit 33 which consists of a square-wave pulse generator 25 and a transistor output stage 27. The square-wave pulse generator 25 generates square-wave pulses which are fed through the transistor output stage 27 as direct-current pulses to the exciter winding of the pole spider 19. The pulse width and possibly also the pulse rate are controlled by a comparator stage 29 which compares the ideal value signal predetermined by the programme control system 11 with an actual value signal corresponding to the actual drive-output rotation speed of the induction coupling 15 and delivers a defect signal determining the pulse width and pulse rate to the square-wave pulse generator 25.

The alternating current motor 7 is made pole-changeable between the pole numbers 2 and 12. In spin-drying operation the program control system 11 through the lead 33 switches on the motor 7 with the pole number 2. At 50 Hz alternating current this corresponds to a rotation speed of the drive-output shaft 13 of about 3,000 revolutions per minute. At maximum spin-drying rotation speed the programme control system 11 gives off an ideal rotation speed value signal which effects a complete excitation of the induction coupling 15. The slip of the induction coupling 15, determined by the difference between drive-input rotation speed minus drive-output rotation speed, in relation to the drive-input rotation speed, is in this case close to zero, that is to say the drive-output rotation speed of the induction coupling also amounts to about 3,000 revolutions per minute. The belt transmission 5 is formed as reduction gearing with a reduction ratio of about 2.8:1 and reduces the drive-output rotation speed of the induction coupling 15 to the maximum spin-drying rotation speed of about 1,000 revolutions per minute. The spin-drying rotation speed can be steplessly further reduced by increase of the slip of the induction coupling 15.

In washing operation the program control system 11 switches on the alternating current motor 7 in twelve-pole operation through a lead 35. With a mains frequency of 50 Hz the drive-output rotation speed of the alternating current motor 7 then amounts to about 500 revolutions per minute, if it is a synchronous motor or less according to the motor slip if it is an asynchronous motor. If the induction coupling 15 were fully excited the drum 3 would be driven with a rotation speed of not quite 180 revolutions per minute. In order to reduce the rotation speed to the desired washing rotation speed of the order of magnitude of 50 revolutions per minute, the program control system 11 increases the slip of the induction coupling 15 to about 0.7. By variation of the slip of the induction coupling 15 the washing rotation speed can be varied within wide limits.

Through a further belt transmission 37 the alternating current motor 7 can drive a washing liquor pump 39 or another auxiliary unit of the drum-type washing machine 1. The washing liquor pump 39 is expediently flanged directly to the free side of the electric motor 7 opposite to the induction coupling. A permanent-magnetically excited coupling 41 is expediently arranged between the drive motor 7 and the pump wheel of the washing liquor pump 39. This coupling 41 serves to limit the torque transmitted to the pump wheel, if the pump wheel is blocked by a foreign body for example in the washing liquor to be pumped away. The liquor pump 39 can in this case be operated either together with the drum 3 or independently thereof, if in the latter case the induction coupling 15 is not excited.

Figure 2 shows constructional details of an induction coupling usable in the washing machine according to Figure 1, parts having the same effect being indicated by the same reference numerals. On the motor shaft 13 of the pole-changeable alternating current motor 7 there is seated fast in rotation a hollow shaft 44 which in turn carries the pole spider 19 fast in rotation. The pole spider 19 comprises an annular coil 45 arranged coaxially with the drive-output shaft 13 and enclosing a soft iron core 47 of sleeve form. The soft iron core 47 is adjoined on the two axial sides by yoke plates 49 and 51 which each carry on their outer circumference a plurality of pole pieces 53 and 55 respectively, distributed over the circumference. The pole pieces 53 and 55 engage axially away over the external circumference of the annular coil 45 between the pole pieces of the other yoke plate respectively. When the annular coil 45 is energised, magnetic fields with alternating polarity in the direction of the circumference of the pole spider 19 develop between the pole pieces 53, 55.

The inductor 21 is formed as a one-piece metal die-casting. It encloses the pole spider 19 and is mounted rotatably coaxially therewith in overhung manner on the hollow shaft 44 through ball bearings 57. The inductor 21 comprises a plurality of short-circuit webs 59 distributed at intervals over the circumference, which are integrally connected on the alternating current motor 7 side with a short-circuit ring 61 and on the side remote from the motor with a bearing hub 63 likewise serving as short-circuit ring. The bearing hub holds the inductor 21 on the hollow shaft 44 through the ball bearings 57 and is provided with a circumferential belt groove 65 for the transmission belt of the belt transmission 5. The short-circuit webs 59 are cast in axially extending grooves 67 on an annular yoke 69 which consists of a plurality of axially stacked and mutually electrically insulated soft iron plates 71.

Two concentric slip rings 73, 75 connected with the terminals of the annular coil 45 are fitted in mutually insulated manner on the pole spider 19 and brushes 77 and 79 respectively brush against them. The brushes 77, 79 are held on an insulating carrier 81 of the adjacent motor housing flange.

In operation exciter current pulses are fed to the annular coil 45 through the brushes 77, 79 and the slip rings 73, 75 and generate between the pole pieces 53, 55 a magnetic field rotating with

the pole spider 19. The magnetic field induces eddy currents in the short-circuit webs 59 and thus a rotation of the inductor 21.

CLAIMS

1. Drive apparatus for a rotating drum (3) of a washing machine (1) operable with at least one washing rotation speed and at least one spin-drying rotation speed, having an electric motor (7), an induction coupling (15) interposed in the force transmission path between the electric motor (7) and the drum (3) and a programme control system (11) which controls the washing operation and the spin-drying operation, characterised in that the electric motor (7) is formed as a pole-changeable alternating current motor which the programme control system (11) switches on in spin-drying operation with a first pole number and in washing operation with a second pole number higher than the first pole number, and in that the induction coupling (15) is connected to a rotation speed regulator circuit (17) which keeps the drive-output rotation speed of the induction coupling (15) at rotation speed values predetermined by the programme control system (11) in spin-drying operation and washing operation respectively, by regulation of the excitation of the induction coupling (15).

2. Drive apparatus according to Claim 1, characterised in that the ratio of the second pole number to the first pole number is selected between 6:1 and 10:1.

3. Drive apparatus according to Claim 2, characterised in that the first pole number is (2) and the second pole number is (12).

4. Drive apparatus according to Claim 1, characterised in that the electric motor (7) is coupled to the drum (3) through a belt transmission (5) having a constant reduction ratio between 2.5:1 and 3.5:1 reducing the drum rotation speed.

5. Drive apparatus according to Claim 1, characterised in that the rotation speed regulator circuit varies the slip of the induction coupling (15) between values of about 0.85 and approximately 0.

6. Drive apparatus according to Claim 1, characterised in that the induction coupling (15) is connected to a pulse driver circuit (23) of the rotation speed regulator circuit (17) which delivers direct-current pulses with pulse rate or pulse width dependent upon the drive-output rotation speed of the induction coupling (15).

7. Drive apparatus according to Claim 6, characterised in that the pulse driver circuit (23) comprises a transistor output stage (27).

8. Drive apparatus according to Claim 1, characterised in that the alternating current motor (7) is coupled both through the induction coupling (15) with the drum (3) and through at least one additional permanent magnetically excited coupling (41) directly with at least one secondary unit (39) of the washing machine (1), especially a washing liquor pump or a fan.

9. Drive apparatus according to Claim 1, characterised in that the induction coupling (15) comprises a pole spider (19) having an exciter winding (45) generating an axially directed magnetic field, and an inductor (21) rotatable coaxially with and relative to the pole spider (19), in that the pole spider (19) comprises a yoke (47, 49, 51) having a yoke plate (49, 51) on each of the two axial sides of the exciter winding (45), in that the yoke plates (49, 51) carry a plurality of pole pieces (53, 55) distributed at mutual intervals over their circumference, which are arranged in the circumferential direction in each case between the pole pieces of the other yoke plate, in that the inductor (21) is formed as a metal die-casting which comprises two short-circuit rings (61, 63) arranged with mutual spacing from one another and coaxial with the pole spider (19) and a plurality of short-circuit webs (59), extending approximately axially and distributed over the circumference, between the short-circuit rings (61, 63), which webs are integrally connected with the short-circuit rings (61, 63), and in that one of the short-circuit rings (63) is at the same time formed as bearing hub for an overhung mounting of the inductor (21).

10. Drive apparatus according to Claim 9, characterised in that the short-circuit webs (59) are cast in axial grooves (67) of a yoke (69) of annular soft iron plate parts (71) stacked axially with mutual insulation.

11. Drive apparatus according to Claim 3, characterised in that the short-circuit ring (63) forming the bearing hub is at the same time formed integrally as drive-output belt pulley (65).

12. Drive apparatus according to Claim 9, characterised in that the pole spider (19) and the inductor (21) are mounted on a common shaft (44) connectable fast in rotation with the drive-output shaft (13) of the alternating current motor (7).

13. Drive apparatus according to Claim 12, characterised in that the common shaft is formed as a hollow shaft (44) which can be pushed fast in rotation on to the drive-output shaft (13).

14. Drive apparatus according to Claim 1, characterised in that the alternating current motor (7) is formed as a single-phase alternating current motor.

15. Drive apparatus for a rotating drum of a washing machine substantially as described herein with reference to the accompanying drawings.

New claims or amendments to claims filed on

Superseded claims 11
New or amended claims:—

11. Drive apparatus according to Claim 9, characterised in that the short-circuit ring (63) forming the bearing hub is at the same time formed integrally as drive-output belt pulley (65).

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1982. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.